



Fermilab

Directorate

**MEMORANDUM OF UNDERSTANDING  
FOR THE 2007 MESON TEST BEAM PROGRAM**

**T964**

**Gas Electron Multiplier (GEM) Chamber Characteristics Test**

**University of Texas at Arlington  
Changwon National University, Korea  
Louisiana Tech University**

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INTRODUCTION	3
I. PERSONNEL AND INSTITUTIONS:	5
II. EXPERIMENTAL AREA, BEAMS AND SCHEDULE	5
III. RESPONSIBILITIES BY INSTITUTION - NON FERMILAB	6
IV. RESPONSIBILITIES BY INSTITUTION - FERMILAB	7
V. SUMMARY OF COSTS	8
VI. SPECIAL CONSIDERATIONS	9
SIGNATURES	11
APPENDIX I - HAZARD IDENTIFICATION CHECKLIST	12

## **INTRODUCTION**

This Memorandum of Understanding covers beam time usage at the Meson Test Beam Facility in March 2007 for tests with three Gas Electron Multiplier (GEM) chambers for the International Linear Collider (ILC) Digital Hadron Calorimeter R&D (DHCAL – University of Texas at Arlington, UTA), for ILC tracker R&D (Louisiana Tech University, LTU) and for radiation imaging detector R&D (Changwon National University, CNU). The memorandum is intended solely for the purpose of providing a work allocation for Fermi National Accelerator Laboratory and the participating universities; UTA, LTU and CNU. It reflects an arrangement that is currently satisfactory to the parties involved. It is recognized, however, that changing circumstances of the evolving research program may necessitate revisions. The parties agree to negotiate amendments to this memorandum to reflect such revisions.

Gas Electron Multipliers (GEM) have been used in many HEP experiments as tracking detectors and are found to be sensitive to X-rays which allows the use beyond that of HEP. The UTA High Energy group has been working on using GEM as the sensitive gap detector in a DHCAL for the ILC. The physics goals at the ILC put a stringent requirement on detector performance. Especially the precision required for jet mass and positions demands an unprecedented jet energy resolution to hadronic calorimeters. A solution to meet this requirement is using the Particle Flow Algorithm (PFA). In order for PFA to work well, high calorimeter granularity is necessary. Previous studies based on GEANT simulations using GEM DHCAL gave confidence on the performance of GEM in the sensitive gap in a sampling calorimeter and its use as a DHCAL in PFA.

The LTU team has been collaborating with UTA in developing GEM foils with 3M Inc. for the use in a tracking detector for the ILC. The CNU team has been collaborating with UTA originally on DHCAL development and is now focusing on using GEM detector as low energy X-ray imaging detectors.

As an initial attempt to measure performance of GEM prototype detectors, one UTA 9-channel GEM chamber and one CNU single channel chamber were exposed to a high intensity low energy (10MeV) electron beam at the Korean Atomic Energy Research Institute (KAERI) in May 2006. The width of this electron beam pulse was 30ps with a repetition rate of 43 kHz, making it very impossible to decipher the signal and understand the performance of the chambers in detail. The exposure, however, gave a good measurement of radiation damage of GEM detector.

In order to have fuller understanding of various chamber characteristics, the experimenters plan to expose one UTA GEM chamber with 1cm×1cm pad granularity with 100 channel simultaneous readout. CNU will use a single channel mini-chamber while LTU will use a 9 channel chamber. The experimenters plan to measure: MiP signal height, chamber efficiencies, performance as a function of HV, gas mixture proportion and position

dependences of efficiency, cross talk and its distance dependence to the triggered pad, chamber rate capabilities and pad occupancy rate.

## **I. PERSONNEL AND INSTITUTIONS:**

Spokesman and Physicist-in-charge:  
Fermilab Liaison:

J. Yu  
E. Ramberg

- 1.1 UTA members: H. Brown, K. Hong, J. Li, C. Medina, J. Smith, A. White, J. Yu
- 1.2 CNU members: C. Hahn, W. Kim, B. Moon, S. Park
- 1.3 LTU members: T. Howe, L. Sawyer

Other commitments:

DØ: L. Sawyer, A. White, J. Yu

ATLAS: J. Li, L. Sawyer, A. White, J. Yu

ILC: H. Brown, J. Li, C. Medina, L. Sawyer, J. Smith, A. White, J. Yu

## **II. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS:**

### 2.1 LOCATION

- 2.1.1 The experiment is to take place in the MTEST beamline and will be situated in the MT6 enclosure. The experimenters' first choice for location in the enclosure is MT6-2C on the existing motion table. Space for a CAMAC crate and a NIM crate, low voltage power supplies and DAQ computers will be needed inside the enclosure. In addition, the main control room to the west of the MTest beamline will be used to house a DAQ control and monitoring computers and should provide a limited amount of work space for five people after the setup completes.

### 2.2 BEAM

- 2.2.1 The tests will use slow resonantly-extracted, Main Injector proton beam focused onto the MTest target. The tests require muon, pion and electron beams.
- 2.2.2 A mixed beam of momentum selected muons (if available), pions and electrons in the 5-20 GeV/c range and 120GeV proton to minimize multiple scattering effects will be needed for MiP identification and various position and HV scans, both transverse and longitudinal. Triggered beam spot sizes (i.e. using a set of three 1cm×1cm finger counters in coincidence with two 19cm×19cm scintillation counters) of about 10 mm<sup>2</sup> for transverse and not greater than 1 cm<sup>2</sup> is desired. The experimenters require a week of dedicated running for these tests.
- 2.2.3 For the above a rate of approximately 100 Hz is assumed.
- 2.2.4 It is not ideal for GEM chambers to run downstream of other detectors that present high radiation lengths material except for the setup stage. High momentum muon runs (if available) will allow such a concurrent running. Also, because of limited manpower the experimenters do not plan to run 24 hours a day. Also given the fact that people are on a restricted time frame, the experimenters plan on having the beam be available for a contiguous one week period with increased duty factor for 12 hours a day. The experimenters plan to run two 6 hour shifts for data taking with a possible 1 - 2 hour overlap for daily planning and assessment.

## 2.3 SETUP

- 2.3.1 The detector setup consists of one UTA 100 channel chamber of dimension 35cm×35cm×5cm, one CNU single channel chamber of dimension 5cm×5cm×2cm and one LTU nine channel chamber of dimension 40cm×40cm×5cm. This chamber array will be surrounded by two 19cm×19cm scintillation counters. These counters will cover the central active area of the chambers.
- 2.3.2 This setup of the three chambers sandwiched by the two large scintillation counters will be placed on the movable table. The coincidence of these two large counters along with three 1cm×1cm finger counters placed in front of the chamber but off the movable array will provide the primary trigger. This setup allows the chamber array to move with respect to the beam location for the position scan. The trigger will be formed using NIM coincidence modules. Space for a NIM crate near the trigger counters is needed. The experimenters will setup trigger counters, using components already in existence at MTBF or at Fermilab equipment pool.
- 2.3.3 Each 1cm×1cm pad in the GEM anode board is connected to a preamplifier mounted on the chamber. The signal from the preamplifiers is then fed into a shaper to increase the width of 50ns chamber signal to 4 – 10  $\mu$ s. The shaper is going to be powered through a CAMAC crate. So the experimenters need a space to hold this CAMAC crate near the chamber array. The signal from the shaper board is then sent to the ADLINK ADC card installed in the DAQ computer via two 2m long SCSI cables. This DAQ computer must be located close to the chamber array inside the enclosure. This computer must be on the local area network since it is controlled and monitored by another computer outside enclosure.
- 2.3.4 Droege HV supplies are used to power chambers, and thus need a rack space to hold and power a NIM crate. The experimenters will also need a rack space to mount three low voltage power supplies.
- 2.3.5 Access to the beam area will be needed periodically for installation and cabling.

## 2.4 SCHEDULE

- 2.4.1 The experimenters will initiate these tests in March of 2007 and propose to complete in two weeks after the start of setup – one week for setup and one week for actual data taking, mixed with rapid return.

## III. RESPONSIBILITIES BY INSTITUTION-NON FERMILAB:

[ ] denotes the replacement cost of existing hardware in USD.

- 3.1 The detectors and electronics will be brought by UTA, CNU and LTU.
- 3.1.1 35cm×35cm×5cm UTA chamber [3K]
- 3.1.2 5cm×5cm×2cm CNU chamber [2K]
- 3.1.3 40cm×40cm×5cm LTU chamber [3K]
- 3.1.4 Electronics cards for the chambers [10K]
- 3.1.5 CAMAC crate with controller [5K]
- 3.1.6 NIM crate, coincidence modules, fan-outs, discriminators [10K]
- 3.1.7 Scope [10K]
- 3.1.8 Pulser [3K]
- 3.1.9 HV and LV Power supplies [10K]

3.1.10	Cables	[1K]
3.1.11	3 sets of PCs and monitors	[5K]
3.1.12	Beam trigger telescope set	[4K]
3.1.13	Pre-mixed ArCO <sub>2</sub> gas in 50" bottles	[2K]
	Total	[\$68K]

#### **IV. RESPONSIBILITIES BY INSTITUTION-FERMILAB:**

##### **4.1 FERMILAB ACCELERATOR DIVISION:**

- 4.1.1 Use of MTest beam as outlined in section 2 above.
- 4.1.2 Maintenance of all existing standard beam line elements (SWICs, loss monitors, etc) instrumentation, controls, clock distribution, and power supplies.
- 4.1.3 A scaler or beam counter signal should be made available in the counting house.
- 4.1.4 Reasonable access to our equipment in the test beam.
- 4.1.5 The test beam energy and beam line elements will be under the control of the AD Operations Department Main Control Room (MCR).
- 4.1.6 Position and focus of the beam on the experimental devices under test will be under control of MCR. Control of secondary devices that provide these functions may be delegated to the experimenters as long as it does not violate the Shielding Assessment or provide potential for significant equipment damage.
- 4.1.7 The integrated effect of running this and other SY120 beams will not reduce the anti-proton stacking rate or protons on target for neutrino production by more than 5% globally, with the details of scheduling to be worked out between the experimenters and the Office of Program Planning.

##### **4.2 FERMILAB PARTICLE PHYSICS DIVISION:**

- 4.2.1 The test beam efforts in this MoU will make use of the Meson Test Beam Facility. Requirements for the beam and user facilities are given in Section 2. The Fermilab Particle Physics Division will be responsible for coordinating overall activities in the MTest beamline, including use of the user beam-line controls, readout of the beam-line detectors and the MTest gateway computer. [0.5 person weeks]
- 4.2.2 The experimenters will require use of the remote controlled motion table, with movement in both vertical and horizontal directions.

##### **4.3 FERMILAB COMPUTING DIVISION:**

- 4.3.1 Ethernet and a printer should be available in the counting house.
- 4.3.2 Connection to beams control console and remote logging (ACNET) should be made available in the counting house.
- 4.3.3 Ethernet should be available inside the beam enclosure to connect the DAQ computer onto the local area network.
- 4.3.4 Beam position tracking system data should be passed to the DAQ computer and written into data files in conjunction with GEM chamber data.

##### **4.4 FERMILAB ES&H SECTION:**

- 4.4.1 Assistance with safety reviews.

**V. SUMMARY OF COSTS:**

Source of Funds	Equipment	Operating	Personnel
Accelerator Div.			
Particle Physics Div.			0.5 person-weeks
Computing Div.			
Totals (Fermilab)			0.5 person-weeks
Totals (non-Fermi)	\$68K		



## **VI. SPECIAL CONSIDERATIONS:**

- 6.1 The responsibilities of the spokesman of the GEM group and the procedures to be followed by experimenters are found in the Fermilab publication "Procedures for Experimenters" (<http://www.fnal.gov/directorate/documents/index.html>). The Physicist in charge agrees to those responsibilities and to follow the described procedures.
- 6.2 To carry out the experiment a number of Environmental, Safety and Health (ES&H) reviews are necessary. This includes creating a Partial Operational Readiness Clearance document in conjunction with the standing Particle Physics Division committee. The spokesman of the GEM group will follow those procedures in a timely manner, as well as any other requirements put forth by the division's safety officer.
- 6.3 The spokesman of the GEM group will ensure that at least one person is present at the Meson Test Beam Facility whenever beam is delivered and that this person is knowledgeable about the experiment's hazards.
- 6.4 All regulations concerning radioactive sources will be followed. No radioactive sources will be carried onto the site or moved without the approval of the Fermilab ES&H section.
- 6.5 All items in the Fermilab Policy on Computing will be followed by the experimenters (<http://computing.fnal.gov/cd/policy/cpolicy.pdf>).
- 6.6 The spokesman of the GEM group will undertake to ensure that no PREP or computing equipment be transferred from the experiment to another use except with the approval of and through the mechanism provided by the Computing Division management. They also undertake to ensure that no modifications of PREP equipment take place without the knowledge and consent of the Computing Division management.
- 6.7 The GEM group will be responsible for maintaining and repairing both the electronics and the computing hardware supplied by them for the experiment. Any items for which the experiment requests that Fermilab performs maintenance and repair should appear explicitly in this agreement.
- 6.8 At the completion of the experiment:
  - 6.8.1 The spokesman of the GEM group is responsible for the return of all PREP equipment, computing equipment and non-PREP data acquisition electronics. If the return is not completed after a period of one year after the end of running the spokesman of the GEM group will be required to furnish, in writing, an explanation for any non-return.
  - 6.8.2 The experimenters agree to remove their experimental equipment as the Laboratory requests them to. They agree to remove it expeditiously and in compliance with all ES&H requirements, including those related to transportation. All the expenses and personnel for the removal will be borne by the experimenters.

- 6.8.3 The experimenters will assist the Fermilab Divisions and Sections with the disposition of any articles left in the offices they occupied, including computer printout and magnetic tapes.
- 6.8.4 An experimenter will be available to report on the test beam effort at a Fermilab All Experimenters Meeting.

**Signatures:**

\_\_\_\_\_/ / 2007  
Jae Yu, University of Texas at Arlington

\_\_\_\_\_/ / 2007  
Greg Bock, Particle Physics Division

\_\_\_\_\_/ / 2007  
Roger Dixon, Accelerator Division

\_\_\_\_\_/ / 2007  
Victoria White, Computing Division

\_\_\_\_\_/ / 2007  
William Griffing, ES&H Section

\_\_\_\_\_/ / 2007  
Hugh Montgomery, Associate Director, Fermilab

\_\_\_\_\_/ / 2007  
Stephen Holmes, Associate Director, Fermilab

## APPENDIX I - Hazard Identification Checklist

Items for which there is anticipated need have been checked

Cryogenics		Electrical Equipment		Hazardous/Toxic Materials	
	Beam line magnets		Cryo/Electrical devices		List hazardous/toxic materials
	Analysis magnets		Capacitor banks		planned for use in a beam line or experimental enclosure:
	Target	X	high voltage (2100V at 1.0mA max) (for SiPMs)		
	Bubble chamber		exposed equipment over 50 V		
Pressure Vessels		Flammable Gases or Liquids			
	inside diameter	Type:			
	operating pressure	Flow rate:			
	window material	Capacity:			
	window thickness	Radioactive Sources			
Vacuum Vessels			permanent installation	Target Materials	
	inside diameter		temporary use		Beryllium (Be)
	operating pressure	Type:			Lithium (Li)
	window material	Strength:			Mercury (Hg)
	window thickness	Hazardous Chemicals			Lead (Pb)
Lasers			Cyanide plating materials		Tungsten (W)
	Permanent installation		Scintillation Oil		Uranium (U)
	Temporary installation		PCBs		Other : Iron (Fe), Ta Cu
	Calibration		Methane	Mechanical Structures	
	Alignment		TMAE		Lifting devices
type:			TEA	X	Motion controllers
Wattage:			photographic developers	X	scaffolding/elevated platforms
class:			Other: Activated Water?		Others